CORTEX 141 (2021) 201–210

Available online at www.sciencedirect.com

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Journal homepage: www.elsevier.com/locate/cortex

Research Report

The presence of placeholders modulates the naso-temporal asymmetry in the remote distractor effect

Soazig Casteau [a], Rebecca Lodge [a], Mary Chalkley [a], Robin Walker [b] and Daniel T. Smith [a,*]

[a] Department of Psychology, Durham University, UK
[b] Department of Psychology, Royal Holloway University of London, UK

ARTICLE INFO

Article history:
Received 15 September 2020
Reviewed 6 November 2020
Revised 21 December 2020
Accepted 1 April 2021
Published online 6 May 2021

Keywords:
Saccade
Remote distractor effect
Naso-temporal asymmetry
Attention

ABSTRACT

The remote distractor effect (RDE) is a well-known and robust phenomenon whereby latencies of saccades are increased when a distractor is presented simultaneously along with the saccade target. Studies of the RDE in patients with a loss of vision in one visual field (hemianopia) following damage to primary visual cortex have provided conflicting results. Rafal, Smith, Krantz, Cohen, and Brennan (1990) reported a naso-temporal asymmetry in the RDE in patients with hemianopias, with a greater influence of distractors presented in their blind temporal visual field. This asymmetry was not observed in typically sighted controls. By contrast, Walker, Mannan, Maurer, Pambakian, and Kennard (2000) observed no effect of distractors presented to either the blind nasal or blind temporal hemifield of hemianopes, but the naso-temporal asymmetry was observed in typically sighted controls. The present study addressed one potential methodological differences between the two studies by investigating the inhibitory effect of a distractor on saccade latency in neurotypical participants. Here participants were tested monocularly and the effect of a nasal/temporal hemifield distractor on saccade latency observed in the presence or absence of peripheral placeholders. Our results showed a naso-temporal asymmetry in the magnitude of the RDE in the no placeholder condition, with a greater RDE when the distractor was presented in the temporal visual field. However, in the placeholder condition the opposite asymmetry was observed, that is an increased RDE when the distractor was presented in the nasal visual field. Our results suggest that the presence/absence of a placeholder might be the critical factor explaining the discrepancy between Rafal et al. (1990) and Walker et al. (2000) in participants without visual field loss. The current results can be interpreted in terms of additional inhibitory or attentional processes that bias selection towards stimuli in the nasal hemifield in the presence of placeholders, still, the mechanisms underlying these effects remain unclear.

* *Corresponding author*. Department of Psychology, Durham University, Durham, DH13LE, UK.
E-mail address: daniel.smith2@durham.ac.uk (D.T. Smith).

https://doi.org/10.1016/j.cortex.2021.04.007

1. Introduction

Eye movements are essential in everyday life, simply because we can see precisely and in detail only when visual stimuli are positioned in the center of the retina, at the fovea. The fovea spans 2° of central vision and is the only part of the eye able to process with high acuity. Because of this, brief periods of fixation are interspersed with frequent eye movements, referred to as 'saccades', allowing to reorient our gaze towards new objects of interest. Saccadic eye-movements are characterized by short latencies (i.e., the time that separates the stimulus onset from the saccade onset) of about 150–175 msec when a single object is presented in the periphery. However, latencies can be modulated by several factors including the presence or absence of a foveal fixation stimulus (Fischer & Breitmeyer, 1987; Saslow, 1967), the orienting of attention (e.g., Sheliga, Riggio & Rizzolati, 1994), the stimulus eccentricity (e.g., Kalesnykas & Hallett, 1994; Weber, Aiple, Fischer & Latanov, 1992), and the presence of a competing distractor (e.g., Casteau & Vitu, 2012; Deubel, Wolf, & Hauske, 1984; Walker, Deubel, Schneider, & Findlay, 1997; Walker, Kentridge & Findlay, 1995).

The influence of a distractor has different, reciprocal effects depending on its spatial location and temporal onset in relation to the saccade target. When a distractor is presented within approximately 20° of the target axis, saccadic endpoint is shifted from the target to an intermediate location between target and distractor, without modulating latency. This effect on saccade amplitude is referred to as 'Global Effect' (Findlay, 1982). By contrast, a distractor appearing outside of this zone increases latency, without modulating amplitude. It has been theorised that these reciprocal effects may demonstrate separate processes for the programming of the spatial and temporal aspects of saccade execution (Findlay & Walker, 1999; Walker et al., 1997).

This increase in saccade latency in the presence of a distractor, termed the 'remote distractor effect' (RDE), is a robust oculomotor effect first demonstrated by Lévy-Schoen (1969) who reported a latency difference of 40 msec between trials with just a target and those with a contralaterally presented distractor. It was proposed that this latency increase was caused by the additional requirement of selecting the target and thus the correct saccade direction. Later experiments, however, in which the location of the target was entirely predictable, found no reduction to the RDE (Weber & Fischer, 1994; Walker et al., 1995; Walker et al., 1997), thus attention and/or decision making cannot be the cause of the delay. An alternative theory suggests instead that it may be due to inhibitory effects acting within the brain regions involved in saccade generation.

It has been proposed that the remote distractor effect reflects mechanisms at the level of the superior colliculus (SC), an integrative and multilayered midbrain structure involved in the computation of saccadic eye-movements (Arai & Keller, 2005; Findlay & Walker, 1999; Kopecz & Schöner, 1995; Meeter, Van der Stigchel, & Theeuwes, 2010; van Opstal & van Gisbergen, 1989). According to Walker et al. (1997), the RDE results from competitive interactions between a 'fixation' system, activated by stimuli presented close to fixation (up to 10° in the periphery), and a 'move' system, activated exclusively by stimuli presented in the periphery. They proposed that saccades are held until the fixation activity falls below a certain threshold (see also Findlay & Walker, 1999) and that the RDE results from activity of this fixation system that is modulated by distance from fixation. The foveal and parafoveal visual field is thought to be represented in the rostralateral part of the SC, and neurons in the rostral pole fire in relationship with fixation. These neurons have been found over an extended area, from the rostral pole region of the SC, which receives input from the 2-degree foveal area, to more caudal parts coding for eccentricities up to 10° (Gandhi & Keller, 1997). Thus, fixation activity is greater when a distractor is presented at fixation or in the periphery, but as the distractor becomes more eccentric and the ratio of distractor to target eccentricity increases, fixation activity competes less largely with saccade-related activity at the target location, and the distractor effect on saccade latency becomes progressively less. Evidence that the magnitude of RDE is influenced by the distance between distractor and fovea (with the largest RDE occurring when the distractor appears at fixation) supports a fixation-related account of RDE (Casteau & Vitu, 2012; Honda, 2005; Walker et al., 1995). The activation distribution hypothesis is also supported by the model of Findlay and Walker (1999). According to these authors, saccade generation occurs in two stages, the first step is a decision level, related to deciding when the eyes should move and in which direction. Then, when the decision to initiate a saccade is made, a neural signal is sent so that saccade amplitude can be computed. Findlay and Walker described a model based on two separate pathways: the 'when' and the 'where'. The 'where' path is linked to the distribution of spatial coding within the SC map; and the 'when' path is based on a single, cumulative signal, the level of which depends on mainly foveal but also peripheral stimulation. The "where" way is linked to the move system and the "when", to the fixation system. These two systems are in constant competition, when one system will increase its activity the other will decrease. As long as the fixation system is above a certain threshold, the saccade cannot take place. It is when the balance between fixation and movement is reached that the saccade can be generated. The time required to resolve the conflict determines when the saccade is generated and therefore the latency of the saccade.

The timing of a distractor can also affect the magnitude of the remote distractor effect. For example, Walker et al. (1995) found the greatest RDE occurred when target and distractor appeared near simultaneously, with distractors appearing $\leq$80 msec either side of target onset producing still significant, but smaller, RDEs. If the distractor was presented 160 msec prior to target onset, on the other hand, a significant latency facilitation effect was observed which was attributed to the distractor acting as a warning signal that stimulates saccade preparation (Ross & Ross, 1980, 1981). It has also been shown that the RDE is greater under binocular viewing conditions than monocularly, but there are no effects of eye dominance (Griffiths, Whittle & Buckley, 2006). The presence of objects, such as placeholders, may also exert an influence on the magnitude of the RDE, and object onset has a much larger and

reliable effect on latency than the offset of an object (Hermens & Walker, 2010).

Cumulatively, these experiments show that, although malleable, the RDE is a robust oculomotor effect. However, one notable exception is a report by Rafal et al. (1990) designed to examine naso-temporal visual field effects in people with visual field defects. Specifically, distractors presented in the temporal blind hemifield of three participants with a loss of vision for one visual field (hemianopia) resulting from stroke affecting the primary visual cortex produced a greater RDE than distractors presented in the blind nasal hemifield. According to Rafal et al., the distractor effect on saccade latency observed in hemianopic patients indicated that in their case the RDE is mediated by the retinotectal pathway from the retina to the SC. According to Rafal's 'retinotectal' theory, the exaggerated RDE elicited by temporal hemifield distractors in hemianopic patients occurred because a greater volume of ganglion cell projections arise from the nasal hemiretina than the temporal hemiretina (see Walker et al., 2000 for discussion of this point). Critical to this argument was the finding that the naso-temporal asymmetry was not observed in the sighted controls, which was taken as evidence that this effect is not mediated by the cortical visual pathway.

The proposal that the retinotectal pathway mediates the naso-temporal asymmetry has been influential and is supported by converging evidence from several studies. For example, Posner and Cohen (1980) observed that when stimuli were presented in both hemifields, participants tended to make more saccades towards the stimulus presented in the temporal compared to the nasal hemifield. Kristjansson and colleagues (2004) reported shorter latencies for saccades directed towards the temporal hemifield. Rafal, Henik, and Smith (1991), using a cueing task (Posner & Cohen, 1984) observed that the attentional benefits from non-informative peripheral valid cues were stronger in the temporal hemifield. These results can be explained by the tight coupling between exogenous attention and the activation of the oculomotor system (e.g., Casteau & Smith 2019; Deubel & Schneider, 1996; Hoffman & Subramaniam, 1995; Kowler, Anderson, Dosher, & Blaser, 1995; Smith & Schenk 2012). However, this naso-temporal asymmetry is not supported by all studies of saccadic performance. For example, Bompas, Sterling, Rafal, and Sumner (2008) and more recently Jóhannesson, Ásgeirsson, and Kristjánsson (2012) did not observe a naso-temporal asymmetry for either saccade latencies or landing position. Furthermore, no significant RDE was observed in the 10 control participants reported by Rafal et al. (1990) and this unexpected absence of distractor effect in the neurotypical participants was not discussed.

Walker et al. (2000) aimed at replicating Rafal et al. (1990) to investigate the apparent anomaly of the absence of the RDE in the control participants. In contrast to Rafal et al.'s findings, they observed that control participants showed a reliable RDE that was significantly larger when distractors appeared in the temporal hemifield compared to the nasal hemifield (15 msec *vs* 8 msec), whereas there was no effect of distractors presented to either the blind nasal or blind temporal hemifield of hemianopes. They argued that the finding of a latency asymmetry does not necessarily infer the involvement of the retinotectal pathway because the asymmetry in retinal ganglion cells is also found in the much larger projections to the lateral geniculate nucleus (LGN) and is therefore also a feature of the primary retino-geniculo-striate pathway. In a study with non-human primates, Williams, Azzopardi, and Cowey (1995) found that the projection of cells to the SC was highly variable, and that ratio of nasal/temporal cells was higher in two monkeys, while it was low for two other ones. Besides, Perry and Cowey (1984) reported that solely 10% of the optic nerve project to the SC in the macaque monkey, while 90% project to the LGN. Both the presence of a RDE with control participants and the absence of RDE with hemianopes led Walker et al. (2000) to question the retinotectal pathway hypothesis, and to propose that the RDE is a default characteristic of the saccadic system that is related to the level of competition between target and distractor involved in saccade selection (Findlay & Walker, 1999).

Rafal et al.'s (1990) findings and subsequent formulation of a retinotectal theory of the RDE have been very influential, but subsequent studies failed to replicate the result, and the precise reasons for this failure remain unclear. However, there are a number of methodological factors that may explain the discrepant results in hemianopic patient, and absence of a remote distractor effect and naso-temporal asymmetry in the neurologically intact control participants described by Rafal et al. (1990).

Firstly, Rafal et al. (1990) used a fixation overlap condition, whereby the fixation point remained present during the presentation of target and distractor, which could have reduced the magnitude of the RDE, whereas most other studies such as Walker et al. (2000) used a zero gap where the fixation point is extinguished. Secondly, Rafal et al.'s (1990) target duration was much shorter than Walker et al. (2000) at 100 msec as opposed to 480 msec. Although stimulus durations of 100–200 msec are commonly used in RDE paradigms (Griffiths et al., 2006; Honda, 2005; Walker et al., 1995), little is known about the influence, if any, of target duration on RDE magnitude. Boch, Fischer and Ramsperger (1984), investigated short-latency express saccades with non-human primates, concluded that as long as the saccade is completed whilst the stimulus is still present, there is no effect on latency. A duration of 100 msec, however, is less than the average saccade latency of 150–175 msec, whilst 480 msec is much greater than average saccade latency, thus there may be an effect on the proportions of express and regular saccades, and therefore mean saccadic reaction times, made under these two stimulus durations.

Potentially most crucially, Rafal et al.'s (1990) experiment also included placeholders (squares 1.8° × 1.8° located 10° to the left and right of fixation) and an increase in their luminance acted as the saccade target and distractor rather than the more usual stimulus onset used in studies of saccadic eye movements. Studies of the remote distractor effect typically involve the abrupt onsets of targets and distractors without the use of placeholders (Casteau & Vitu, 2012; Born & Kerzel, 2008; Buonocore & McIntosh, 2008; Griffiths et al., 2006; Honda, 2005; Walker et al., 1995, 1997, 2000; Weber & Fischer, 1994), and the potential influence of placeholders on the RDE has not been studied. However, as previously described, Findlay and Walker (1999) suggest that saccades latencies

depend on the resolution of a competition between a fixation and a move system, a saccade being triggered when the fixation system falls under a certain threshold. As the fixation system may extend up to 10° in the periphery, placeholders presented in both hemifields may increase the activation of the fixation system at the expense of the move system, and in turn, increase saccade latency. Furthermore, the use of placeholders is common in studies of visual perception and attention, and the presence of an object in the visual field before the eye-movement is executed affects perception and attention. For example, Taylor, Chan, Bennett, and Pratt (2015) observed a classical attention facilitation for a target presented at a cued placeholder location compared to uncued placeholder location. However, in a condition where there was no placeholder, they did not observe this attentional facilitation. The presence or absence of a placeholder may therefore be a critical factor in determining the magnitude of the RDE.

Here, we addressed these issues with a partial replication of Rafal et al. (1990) and Walker et al. (2000) by examining the effects of placeholder (placeholder *vs* no placeholder), stimulus duration (100 msec and 480 msec) and the visual field of the target (Nasal or Temporal) on the RDE. If, as suggested by Walker et al. (2000), the RDE is a default response of the oculomotor system, then we should observe an increase in saccade latency when the target is simultaneously presented with a distractor in the opposite hemifield (distractor effect). Secondly, if as suggested by Findlay and Walker (1999), the RDE is result of a competition between an extended fixation system and a move system, longer latencies would be predicted in the placeholder condition compared to the no placeholder condition, as the irrelevant placeholder for the goal directed saccade task might act like a visual distractor. Finally, we expect an interaction between the presence or absence of placeholders and the hemifield of the distractor, such that in the no-placeholder condition we should observe a larger RDE when distractors appeared in the temporal hemifield compared to the nasal hemifield (Walker et al., 2000). Understanding the possible contribution of the placeholder to the naso-temporal asymmetry in saccade latency and the RDE is the therefore the primary motivation of this study.

2. Methods

2.1. Participants

Ten individuals participated in this experiment (6 Female, 9 right-handed mean age of 34 years old). We adopted a sample size of ten participants based on the size of the neurotypical population tested in the study of Rafal et al. (1990) (n = 10) and Walker et al. (2000) (n = 8). Participants were tested monocularly with their dominant eye; the non-dominant eye was patched (see Smith, Ball & Ellison, 2014, for eye dominance assessment procedure). All participants were right-eye dominant, all reported having normal vision and were unaware of the purpose of the experiment. Informed consent was obtained prior to their participation and the study was approved by the Department of Psychology Research Ethics Committee of Durham University and was conducted in accordance with the BPS code of ethics.

2.2. Stimulus material and equipment

Stimuli were generated using a Cambridge Research Systems ViSaGe graphics card and displayed on a 17-inch Sony Trinitron CRT monitor with a 100 Hz refresh rate, at a viewing distance of 540 mm away from participant's eyes. Target/Distractor were white filled squares (2 ° × 2 °), 12 cd/m^2 in luminance and presented at 8.5° eccentricities along the horizontal meridian against a black background (.01 cd/m^2). Placeholders were white square empty boxes (2 ° × 2 °). Fixation consisted of a white '+' sign cross. Eye-movements were recorded using a Cambridge Research Systems Video eyetracker Toolbox sampling at 250 Hz. Head movements were restrained with a chin rest. Saccades were automatically identified offline using a velocity criterion of ≥70°/s. When a potential saccade was identified the algorithm backtracked by 5 samples and recorded this value. The start of the saccade was then found by looking for the first velocity above this smaller pre-start threshold. The raw signal was unfiltered and the detection algorithm was visually verified for every trial.

2.3. Design and procedure

There were four block types: temporal distractor (nasal target) with placeholders, nasal distractor (temporal target) without placeholder, temporal distractor (nasal target) with placeholders, nasal distractor (temporal target) without placeholder. The order of testing for block type was counterbalanced across participants. Within each block, half of the trials consisted of the target being presented alone (no distractor condition—the placeholders remained visible in these trials during the placeholder condition) and in the other half the distractor and target were presented simultaneously and bilaterally (distractor condition). Half of the trials had a stimulus duration of 100 msec and half a stimulus duration of 480 msec. Both stimulus duration and distractor trials were randomly interleaved.

Each block of trials started after a 9 point horizontal and vertical calibration routine. Each trial started with the presentation of a fixation cross (no placeholder) or a fixation cross and two peripheral square shapes (placeholder) (see Fig. 1). After a random interval of between 1000 and 1500 msec, either the target alone (no distractor condition) or both target and distractor (distractor condition) were presented simultaneously. In the placeholder condition, target and distractor consisted of a sudden brightening of one (no distractor condition) or two (distractor condition) boxes. Participants were asked to move their eyes as quickly and as accurately as possible to the target, while ignoring the distractor. Target side was fixed; participants were instructed before the start of each block to make a saccade either to the left or the right side of the fixation cross. As all participants were right-eye dominant, saccades towards the left side were directed at nasal targets, while saccades towards the right side were directed at temporal targets.

There were 40 repetitions per combination of each factor level, resulting in a total of 640 trials. These were divided into 8 blocks of 80 trials, 2 blocks in the no placeholder/nasal, 2 blocks in the no placeholder/temporal, 2 blocks in the placeholder/nasal and 2 blocks in the placeholder/temporal. Half

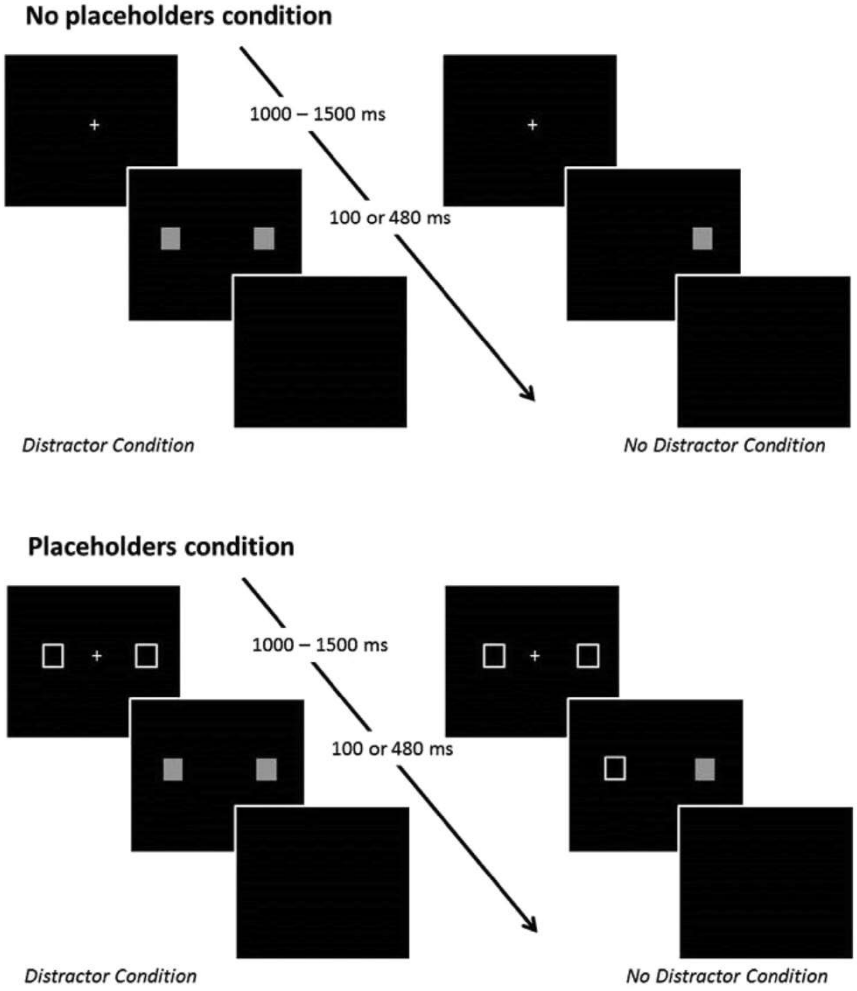

Fig. 1 – Sequence of events in distractor and no distractor conditions for the No Placeholders (top) and Placeholders (bottom) conditions for a saccade-target presented on the right. Saccade target direction was blocked, participants were instructed to make a saccade towards the left (target nasal) or the right (target temporal) at the beginning of each block of trials.

the participants started with the no placeholder blocks and the other half with the placeholder blocks. The order of the blocks were counterbalanced using a Latin square method. A practice block of 20 trials was run before each placeholder/hemifield combination, resulting in a total of 80 practice trials and 4 practice blocks.

No part of the study procedures or analyses was preregistered prior to the research being conducted.

3. Results

3.1. *Data pre-processing*

Data were filtered to remove anticipations (SRT <80 msec, 13.1%), saccades erroneously directed towards the distractor's direction (6.2%) and trials where the eye-tracking signal had been lost (2.8%). Participants were considered as outliers if their average saccade latencies exceeded two and a half standard deviations from the sample mean. Based on these criteria, none of our participants were considered as outliers and the data for all ten were included in the analysis.

Saccade amplitude was examined in each condition. Saccades slightly undershot the target position (i.e., 8.5°), whether the target was presented alone or with a distractor (8.20 and 8.22° average amplitude for distractor and no distractor conditions respectively). For both conditions, saccade amplitude was slightly shorter when the target was presented in the Nasal visual field (8°) compared to the Temporal visual field (8.4°), however target side did not significantly affect saccade amplitude ($F_{(1,9)} = 1.94$, $p = .2$,$\eta_p^2 = .19$), nor did it interact with any other factors (placeholder x side: $F_{(1,9)} = .75$, $p = .409$,$\eta_p^2 = .08$; condition x target: $F_{(1,9)} = 4.06$, $p = .078$,$\eta_p^2 = .33$).

Target duration did not have a significant main effect on latency ($F_{(1,9)} = 1.57$, $p = .241$,$\eta_p^2 = .14$) and did not interact with any of the other variables (time x placeholder: $F_{(1,9)} = .04$, $p = .845$,$\eta_p^2 = .004$, time x target side: $F_{(1,9)} = .14$, $p = .709$,$\eta_p^2 = .01$, time x distractor condition: $F_{(1,9)} = .02$, $p = .873$,$\eta_p^2 = .002$) and so data were collapsed across the two presentation durations. Analyses were achieved using R 3.0.3 (R Core Team, 2014), data visualisation was performed with the package ggplot2 (Wickham, 2016) and Bayes analysis were performed using the BayesFactor package (Morey & Rouder, 2015).

3.2. Data analysis

The median saccade latencies were subjected to a 2 (distractor condition: distractor *vs* no distractor) x 2 (distractor side: nasal *vs* temporal) x 2 (placeholder condition: no placeholder *vs* placeholder) repeated measures ANOVA. The analysis revealed a significant main effect of distractor condition, such that saccade latency was slower on distractor trials than no distractor trials (190 msec *vs* 182 msec; $F_{(1,9)} = 9.15$, $p = .014$,$\eta_p^2 = .50$) and a main effect of placeholder, such that saccade latency was shorter for no placeholder trials (174 msec *vs* 198 msec; $F_{(1,9)} = 5.14$, $p = .049$,$\eta_p^2 = .36$). There was also a significant 3-way interaction between distractor side, placeholder condition and distractor condition $F_{(1,9)} = 7.26$, $p = .025$,$\eta_p^2 = .45$) (Figure2). The interaction was explored using 2 (distractor condition) x 2 (hemifield) ANOVAs at each level of placeholder condition.

For the no placeholder condition a significant main effect of distractor condition was observed ($F_{(1,9)} = 5.33$, $p = .046$,$\eta_p^2 = .37$), such that latencies were longer in the distractor condition compared to the no distractor condition (i.e., the RDE). We also observed a significant interaction ($F_{(1,9)} = 8.92$, $p = .015$,$\eta_p^2 = .49$), such that distractors in the temporal hemifield produced a RDE of 14.43 msec ($t_{(9)} = 3.35$, $p = .008$, $d = .28$), whereas distractors in the nasal hemifield did not elicit a RDE ($t_{(9)} = .34$, $p = .734$, $d = .04$) (see Fig. 2 (a)).

In the placeholder condition there was a significant effect of distractor condition, such that latencies were slower when a distractor was present ($F_{(1,9)} = 6.27$, $p = .033$,$\eta_p^2 = .41$). The interaction was not statistically significant ($F_{(1,9)} = 2.24$, $p = .16$,$\eta_p^2 = .19$). However, planned comparisons (paired samples *t*-tests) revealed an RDE of 14 msec for nasal hemifield distractors (target temporal), ($t_{(9)} = 2.44$, $p = .036$, $d = .43$), but not for temporal distractors (target Nasal), ($t_{(9)} = 1$, $p = .34$, $d = .06$) (see Fig. 2 (b)). The RDE is presented in Fig. 2 (c) and individual data presented in Table 1.

To further investigate whether the presence of a distractor increased saccade latency (RDE) (alternative hypothesis), or if the presence of the distractor did not affect saccade latency (null hypothesis), Bayesian one-sided paired sample *t*-tests were performed using the default Cauchy prior (scale: .707). Comparisons were based on BF_{10} scores, a $BF_{10} > 3$ indicated moderate evidence for the alternative hypothesis, a $BF_{10} > 10$ indicates strong evidence for the alternative hypothesis, while a $BF_{10} < 1$ indicates anecdotal evidence for the null hypothesis and a $BF_{10} < .03$ a moderate evidence for the null hypothesis (Lee & Wagenmakers, 2013).

The planned tests provided strong evidence for a RDE effect in the No placeholder condition when the distractor was presented in the temporal hemifield ($BF_{10} = 14$), and a moderate evidence for the absence of RDE when distractor was nasal ($BF_{10} = .24$). In the Placeholder condition, the analysis showed a moderate evidence for a RDE when distractor was presented in the nasal hemifield ($BF_{10} = 4.32$) and an anecdotal evidence for the absence of a RDE when the distractor was presented in the temporal hemifield ($BF_{10} = .75$).

4. Discussion

Rafal et al. (1990) described an increase in saccade latency (remote distractor effect–RDE) when a distractor was presented in the blind field of three hemianopic participants, when presented in their temporal visual field only. Neurotypical

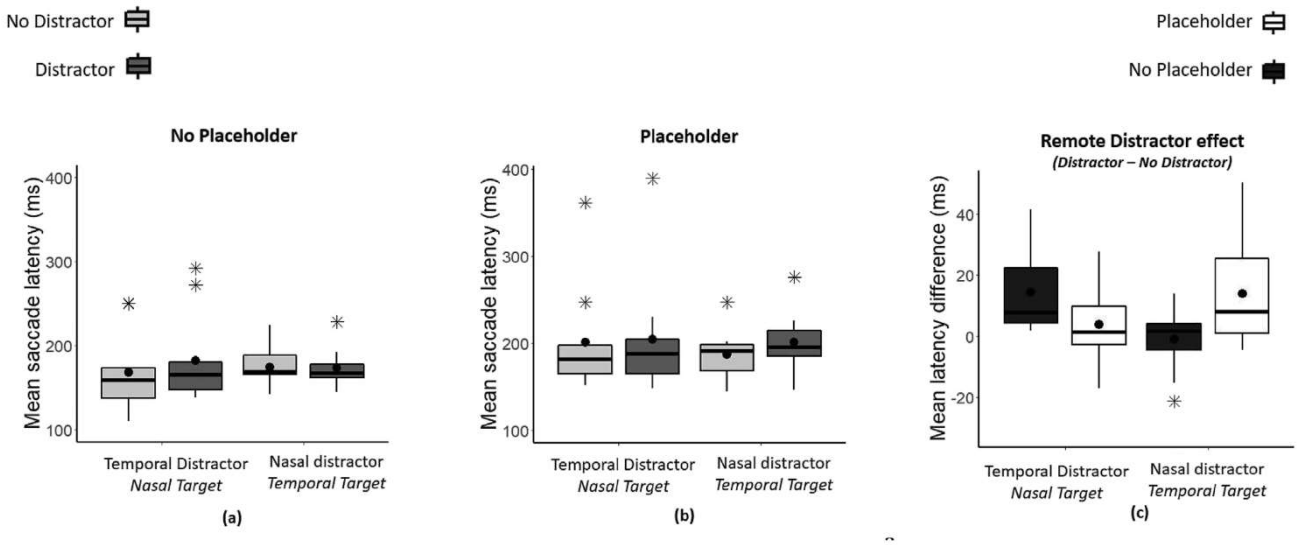

Fig. 2 – Standard box plot (box-and-whiskers plot) showing the lower (Q1) and upper (Q3) quartiles, the median (—) and the mean (●) for saccadic reaction times in the different distractor, placeholder and hemifield conditions. Data falling outside the Q1- 1.5 InterQuartile Range and Q3 + 1.5 InterQuartile Range (✳) are considered as outliers of the data. Mean saccade latency (in ms) in the no placeholder condition (a) and placeholder condition (b) as a function of distractor condition (distractor and no distractor) and nasal/temporal distractor sides across 100 and 480 msec duration and. (c) Mean saccade latency difference between the distractor and no distractor conditions the RDE (in ms), as a function of placeholder condition and distractor side across 100 and 480 msec presentation duration.

Table 1 – Median saccade latency (ms) for the ten subjects. Latency difference is the median latency from the distractor trials minus the median latency for the no-distractor trials (ms). Data as well as R code for the analysis are available https://osf.io/8basv/.

	No placeholder No Distractor		No placeholder Distractor		Placeholder No Distractor		Placeholder Distractor	
	Nasal Target	Temporal Target	Nasal Target	Temporal Target	Nasal Target	Temporal Target	Nasal Target	Temporal Target
Participant 1	173	165	175	161	178	196	189	191
Latency Difference	–	–	+1.75	−4.25	–	–	+10.75	−4.50
Participant 2	142	142	147	152	169	193	164	226
Latency Difference	–	–	+5	+9.5	–	–	−4.5	+33
Participant 3	127	169	148	164	247	202	230	216
Latency Difference	–	–	+20.75	−4.5	–	–	−17	+14
Participant 4	174	190	182	193	201	199	202	200
Latency Difference	–	–	+8.5	+2.5	–	–	+1.5	+0.5
Participant 5	251	165	292	179	188	169	205	168
Latency Difference	–	–	+41.5	+14	–	–	+17	−1
Participant 6	150	169	158	170	164	168	164	183
Latency Difference	–	–	+7.25	+.75	–	–	−0.5	15
Participant 7	250	224	273	229	361	247	389	276
Latency Difference	–	–	+22.75	+4.5	–	–	+27.75	+29
Participant 8	169	190	173	174	186	190	187	192
Latency Difference	–	–	+4.25	−15.5	–	–	+1.25	+2.25
Participant 9	136	143	139	145	152	145	148	147
Latency Difference	–	–	+2.5	+2.5	–	–	−3.75	+1.5
Participant 10	110	187	140	165	162	162	169	212
Latency Difference	–	–	+30.1	−21.4	–	–	+6.9	+50.25
Overall	168	174	183	173	201	187	205	201

control participants did not show a naso-temporal asymmetry in their RDE. By contrast, Walker et al. (2000) did not find any naso-temporal asymmetries in the magnitude of the RDE in a group of six hemianopic patients, but did observe a greater effect of temporal field distractors in neurologically intact controls. These results challenged the conclusions of Rafal et al. (1990), who suggested that the greater RDE with distractors in the temporal visual field was due to the strength of the direct retinal projections to the SC (retinotectal pathway) from the nasal hemiretina. There were methodological differences between these two studies that may account for the differences in the naso-temporal asymmetry in the RDE. The present experiment examined the RDE using neurotypical participants under monocular viewing conditions to establish which of these methodological differences can account for the differences between these two reports.

In the *no placeholder condition*, a naso-temporal asymmetry was observed in the magnitude of the RDE effect. Consistent with Walker et al. (2000), we observed a RDE only when the distractor was presented in the temporal visual field (nasal hemiretina). This result is consistent with evidence that stimuli in the temporal hemifield trigger longer latency saccades in the antisaccade task (Kristjánsson, Vandenbroucke, & Driver, 2004), which was attributed to enhanced competition by temporal hemifield stimuli. More specifically, in the no-placeholder condition here the onset of target and distractor occurred in both visual fields simultaneously. To be able to execute the correct saccade towards the target in one hemifield, participants would have to inhibit the computation of an incorrect saccade towards the opposite hemifield. Rafal et al. (1991) reported that targets in the temporal hemifield tend to lead to faster saccades, thus, computing a saccadic eye-movement away from a signal in the temporal hemifield should delay saccade triggering because of a stronger signal to overcome. Thus, the inhibition of the saccade towards the distractor location in a RDE paradigm might be harder to overcome when the distractor appears in the temporal hemifield, accounting for the increase in saccade latency.

In the *placeholder condition* the opposite pattern was observed, with an increase in the RDE when the distractor appeared in the nasal visual field, but there was no RDE when presented in the temporal visual field. On first inspection this observation appears inconsistent with Rafal et al. (1990) who reported no RDE in the healthy control participants when placeholders were used. However, closer examination of Figure 3 in Rafal et al. (1990) shows some slowing of latency, but only for nasal visual field distractor. This result is broadly similar to the finding here of a larger RDE for nasal visual field distractors in the placeholder condition. It is not clear why a larger RDE was observed for nasal hemifield distractors in placeholder conditions. However, one speculative explanation may be that the sudden onset of the placeholders triggered a transient reflexive shift of attention, followed by a sustained Inhibition of Return (e.g., Posner, Rafal, Choate, & Vaughan, 1985). IOR is known to affect saccade latencies, persists for up to 3s, and has been reported to be larger in the temporal than nasal hemisphere (Rafal, Calabresi, Brennan & Sciolto, 1989). Christie, Hilchey, and Klein (2013) looked at the effect of multiple cues on saccadic IOR. They showed that simultaneous cue presentation elicits small but measurable IOR effects at individual cue location. If the sudden onset of the placeholder generated an IOR, it may be the case that the target was subject to greater IOR than the distracter in the nasal distractor/temporal target condition, thus delaying saccade onset. The opposite may occur for the nasal target/temporal distractor condition. Here, the distractor is subject to greater IOR than the target, so its ability to delay saccade onset is reduced. The proposal that the unexpected pattern of RDE effects in the placeholder condition reflects asymmetric activation of IOR in the nasal and temporal hemifields is also consistent with the finding that saccade latencies were significantly longer in the placeholder condition than non-placeholder condition, as the presence of IOR at both locations will have the overall effect of retarding saccade latency.

An alternative, but not necessarily mutually exclusive explanation for the main effect of the placeholder is that it reflects an additional element of competition in the oculomotor system introduced by the presence of the placeholders. The latencies observed in the target alone condition seem to support the competition between target/distractor and fixation/move system, as longer latencies were observed in the placeholder, compared to the no placeholder, condition. The average latency observed in the no placeholder condition ($M_{latency}$ = 171 msec) is comparable to our other findings (Casteau & Vitu, 2012 – Exp.1) in a target only condition, whereas the latency observed in the placeholder condition ($M_{latency}$ = 194 msec) is greater and more comparable to that observed in the distractor condition. Hence, the presence of a placeholder in the opposite visual field to the target might act to increase the level of inhibition as would a remote distractor onset.

To summarize, the present study examined possible the methodological differences between Rafal et al. (1990) and Walker et al. (2000) that might account for differences reported in naso-temporal asymmetries on the magnitude of the remote distractor effect. The presence or absence of a placeholder appeared to be the critical factor. The precise mechanisms driving these differences are not clear, although we speculated that the presence of placeholders may afford the engagement additional inhibitory or attentional processes that bias selection towards saccade targets in the nasal hemifield. These data demonstrate that the structure of a visual scene can exert a subtle influence on saccade latency effects.

Data inclusion statement

We report how we determined our sample size, all data exclusions, all inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all manipulations, and all measures in the study.

Open practices

The study in this article earned Open Data and Open Materials badges for transparent practices. Raw data as well as summarized data are available on osf: https://osf.io/8basv/.

Funding sources

This research has been supported by the ESRC grant (ES/N018842/1) awarded to DS.

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